

MONTHLY WEATHER REVIEW.

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INTRODUCTION.

The REVIEW for June, 1894, is based on reports from 3,064 stations occupied by regular and voluntary observers. These reports are classified as follows: 148 reports from Weather Bureau stations; 41 reports from U. S. Army post surgeons; 2,059 monthly reports from State weather service and voluntary observers; 34 reports from Canadian stations; 205 reports through the Southern Pacific Railway Company; 468 marine reports through the co-operation of the Hydrographic Office, Navy Department, and "New York Herald Weather Service;" monthly reports from 36 U. S.

Life-Saving stations; 73 reports from navigators on the Great Lakes; monthly reports from local services established in all States and Territories; and international simultaneous observations. Trustworthy newspaper extracts and special reports have also been used.

The WEATHER REVIEW for this month has been prepared under the general editorial supervision of Prof. Cleveland Abbe. The statistical tables are furnished by the Division of Records and Meteorological Data, in charge of Mr. A. J. Henry, acting chief of that division.

CHARACTERISTICS OF THE WEATHER FOR JUNE, 1894.

The most prominent meteorological features of the month of June were the absence of extensive and destructive cyclonic storms in the United States; the occurrence of the groups of violent local storms, many of them having the characteristics of tornadoes, on the 27th in Minnesota, South Dakota, and Kansas, and the areas of severe thunderstorms on the 20th

in Nebraska and Iowa, and the 24th to 27th, from Missouri to Ohio; the abnormal high average temperatures of the upper Lake and North Dakota regions, and the corresponding low temperatures of the middle plateau region; the large rainfall of the middle Rocky Mountain slope, and the large deficiency of the upper Mississippi Valley and east Gulf States.

ATMOSPHERIC PRESSURE.

[In inches and hundredths.]

The distribution of mean atmospheric pressure reduced to sea level, as shown by mercurial barometers not reduced to standard gravity and as determined from observations taken daily at 8 a. m. and 8 p. m. (seventy-fifth meridian time), during June, 1894, is shown by isobars on Chart II. That portion of the reduction to standard gravity that depends on latitude is shown by the numbers printed on the right-hand border. This Chart also gives the so-called resultant wind directions for this month, based on the data given in Table IX of this REVIEW.

During the current month of June the pressures at sea level have been highest on the immediate coast of the south Atlantic States, where it has averaged 30.10. Pressure has been lowest in Assiniboia and Saskatchewan, 29.75, or less; an equivalent area of low pressure has also prevailed at the head of the Gulf of California. These two regions of low pressure represent the trough existing between the high pressures on the Atlantic and Pacific oceans.

The normal distribution of atmospheric pressure and normal resultant wind direction for the month of June were approximately shown on Chart V of the REVIEW for June, 1893, as computed by Prof. H. A. Hazen, and are not now reproduced. As compared with the normal for June, the mean pressure for the current month was in excess throughout the greater part of the United States, the maximum excess

being 0.07 in Arkansas and on the coast of the south Atlantic States. The pressure was below the normal in the British Possessions and the northern border of the United States. The area over which the deficit was 0.05 to 0.08 covered South Dakota, northern Montana, Athabasca, and Alberta.

As compared with the preceding month of May pressure had risen throughout the Middle States, Ohio Valley, and southward to the Gulf, the maximum rise being 0.10 on the coast of North Carolina. Pressure had fallen over the Missouri Valley, eastern Rocky Mountain slope, and northward to British America, the maximum fall being from 0.10 to 0.18 in Manitoba, North Dakota, Assiniboia, and Athabasca.

DIURNAL VARIATIONS.

The systematic periodic diurnal variations of pressure are shown by the hourly means given in Table VI.

AREAS OF HIGH AND LOW PRESSURE.

The following sections give some details as to the phenomena attending the individual areas of high and low pressure. The storm warnings officially issued either by the Weather Bureau through the general forecast official at Washington, or by the respective local forecast officials, are enumerated in connection with the respective areas of disturbance.

MOVEMENTS OF CENTERS.

The following table shows the date and location of the

center at the beginning and ending of each area of high or low pressure that has appeared on the U. S. Weather Maps during the month, together with the average daily and hourly velocities. The monthly averages will differ according as we consider each path as a distinct unit, or give equal weight to each hour of observation; in the first case the monthly average is taken by paths, in the latter case by hours.

Movements of centers of areas of high and low pressure.

Number.	First observed.			Last observed.			Path.		Average velocities.	
	Date.	Lat. N.	Long. W.	Date.	Lat. N.	Long. W.	Length.	Duration.	Daily.	Hourly.
Low areas.										
I.	1, a. m.	0	0	2, a. m.	25	81	Miles.	Days.	Miles.	Miles.
II.	1, a. m.	78	4	4, p. m.	48	64	400	1.0	400	17
III.	2, p. m.	74	121	7, p. m.	51	114	1,500	3.5	486	20
IV.	1, a. m.	108	1	1, p. m.	50	102	1,400	9.0	700	29
V.	6, a. m.	80	6	6, p. m.	35	75	400	0.5	.....	.....
VI.	8, p. m.	49	70	10, a. m.	49	59	300	0.5	.....	.....
VII.	.....	.....	.....	.....	.....	.....	550	1.5	366	15
VIII.	9, p. m.	51	114	13, p. m.	41	104	1,200	4.0	300	13
IX.	10, p. m.	69	106	17, p. m.	47	59	2,450	3.5	700	29
X.	16, a. m.	97	19	19, p. m.	48	75	1,450	5.5	414	17
XI.	16, p. m.	54	116	18, p. m.	55	105	450	1.0	450	10
XII.	19, a. m.	42	105	21, a. m.	53	107	400	2.0	200	8
XIII.	21, a. m.	101	.....	.....	.....	.....	.....	.....	.....	.....
XIV.	21, p. m.	115	.....	23, a. m.	46	97	950	1.5	633	26
XV.	23, a. m.	39	109	24, p. m.	37	105	850	1.5	432	10
XVI.	23, p. m.	114	.....	25, p. m.	52	98	800	2.0	400	17
XVII.	24, p. m.	50	114	25, p. m.	52	74	700	1.0	700	29
XVIII.	24, a. m.	87	111	27, a. m.	54	101	450	1.0	450	19
XIX.	26, a. m.	55	102	29, p. m.	54	65	2,200	4.0	550	23
XX.	26, p. m.	40	67	30, p. m.	56	100	500	2.0	300	13
XXI.	28, a. m.	44	111	30, a. m.	28	80	300	0.5	.....	.....
XXII.	28, p. m.	54	85	30, a. m.	28	102	600	1.5	400	17
XXIII.	29, p. m.	31	.....	.....	.....	.....	.....	.....	.....	.....
XXIV.	28, p. m.	55	.....	.....	.....	.....	.....	.....	.....	.....
Sums	.....	.....	.....	.....	.....	.....	17,750	38.0	7,881	.....
Mean of 17 paths	.....	.....	.....	.....	.....	.....	.....	.....	464	19
Mean of 38 days	.....	.....	.....	.....	.....	.....	.....	.....	467	19
High areas.										
I.	1, a. m.	39	99	3, a. m.	31	94	800	2.0	400	17
II.	2, a. m.	46	109	3, a. m.	48	100	900	1.0	900	38
III.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
IV.	4, a. m.	53	102	9, a. m.	35	75	2,500	5.0	500	21
V.	8, a. m.	39	123	9, a. m.	41	113	500	1.0	500	21
VI.	11, a. m.	33	81	16, a. m.	34	79	1,800	5.0	350	15
VII.	12, a. m.	43	125	18, a. m.	52	87	2,200	6.0	357	15
VIII.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
IX.	23, p. m.	50	66	24, a. m.	44	63	500	0.5	.....	.....
Sums	.....	.....	.....	.....	.....	.....	9,200	20.5	3,127	.....
Mean of 6 paths	.....	.....	.....	.....	.....	.....	.....	.....	521	21.7
Mean of 20.5 days	.....	.....	.....	.....	.....	.....	.....	.....	449	18.7

HIGH AREAS.

Owing to the northerly declination of the sun during the month of June, the so-called equatorial belt of calms lies decidedly north of its position in December and the large areas of high pressure, representing parts of the so-called tropical belt of high pressure, lie still farther north of their winter position; moreover, these centers over the Pacific and Atlantic oceans, respectively, are farther apart than in January, that is to say, the Pacific area lies farther to the west and the Atlantic area farther to the east and, as a consequence, the motions of the small areas of high and low pressure that circulate around these larger areas are slower as they move from the Pacific southeastward into the interior of North America, and northeastward from that interior toward the Atlantic. The troughs and belts of low pressure, both over the Rocky Mountain region and British America, are now more frequent and persistent than the areas of high pressure, still the latter frequently occur, and by their movements and temperatures show that some of them represent slowly descending air that is kept cool by radiation, while others represent rapidly descending air that is warmed by compression faster than it can be cooled by radiation. The low temperature is characteristic of the high areas that descend from the

northwest as offshoots from the Pacific high; the high temperature is characteristic of the areas that move up from the southeast or southwest as the more rapidly descending portions of the tropical areas and especially of that over the Atlantic. The fact that the North American high areas of June and July do not present pressures as high as those that occur in January is largely a result of the higher summer temperature on the land as compared with the ocean, causing a withdrawal of the warmer air from the Eastern and Western continents and a corresponding rise of pressure over the Atlantic, the Pacific, and the Arctic regions.

I.—This was central in Kansas July 1, a. m., and moved southeastward until the 3d, a. m., when it was central in Louisiana.

II.—This was central on the 2d, a. m., in Montana; it stretched southward as a ridge connecting with high area No. I on the 2d, p. m., but afterward extended southeastward and on the 3d, a. m., was central in North Dakota, after which it disappeared.

III.—This number is given to the high pressure off the Pacific coast of California and which occasionally pushes eastward over that State. The principal dates of high pressures on this coast were: 8th, a. m., 30.30, at Eureka, with cold, light winds, clear weather, and occasional frosts in Nevada and California; 12th, a. m., 30.26, at Portland, Oreg., and 30.24 at Eureka, with light winds, clear, cold weather, and frosts in Nevada; 20th, a. m., 30.18, at Portland, Oreg.; 23d, a. m., 30.12, at Portland, Oreg.; 24th, p. m., 30.10, at Eureka; 26th, a. m., 30.18, at Portland, Oreg., and 30.14 at Roseburg and Eureka; 26th, p. m., 30.20, at Eureka; 30th, a. m., 30.24 at Portland, Oreg., and 30.22 at Seattle. These dates of highest pressure on the Pacific coast represent also dates on which areas of low pressure prevailed in the interior of the continent and also generally dates on which small areas of high pressure detaching themselves from the larger Pacific area began to move eastward over the Rocky Mountain region.

IV.—This appeared on the 4th, a. m., in Manitoba, and by the 5th, a. m., pressure had increased, with northerly winds and light frost, in North Dakota. The central highest pressure moved southward, and by the 6th, a. m., was central in Iowa; 6th, p. m., in Missouri; 7th, a. m., in northern Arkansas; 7th, p. m., in western Tennessee; after which it moved eastward, and by the 8th, p. m., had joined the Atlantic high off the North Carolina coast. This movement, therefore, represents in general the same southeastward movement of masses of cold, dry air that we are familiar with in the winter season; it may, in fact, be considered either as a part of the horizontal circulation around the tropical high pressure of the Pacific Ocean or as a part of the vertical circulation by reason of which the warm air of the torrid zone, after rising and overflowing toward the pole, cools and descends slowly, reaches the surface at about N. 50° and returns as an underflow toward the equator.

V.—This area began as a high pressure steadily encroaching on the coast of California until the 8th, a. m., when pressure was highest in that region. By the 8th, p. m., pressure was highest in Nevada; 9th, a. m., in Utah, this being the eastern extremity of the high pressure over the Pacific and forming a ridge that very nearly connected the latter with high area No. IV over the south Atlantic States, but this entirely disappeared before the 10th, a. m., being replaced by a general depression from Mexico to British America.

VI.—This represents the westward encroachment upon the south Atlantic States of the Atlantic area of high pressure. On the 11th, a. m., pressure was highest in South Carolina, and by the 12th, a. m., in western Kentucky; 13th, a. m., in Illinois and Missouri, but by the 14th, a. m., in Maryland and New Jersey, having been reinforced by an additional inflow from the Atlantic Ocean. The center now moved

southwest into Virginia, and by the 16th, a. m., was again in South Carolina.

VII.—This appeared on the 12th, a. m., in Oregon, moved very slowly eastward, and was in Montana on the 15th, a. m., at which time the ridge of high pressure stretched from Alberta to the Gulf of Mexico and the south Atlantic States. No. VII represents the northern end of this ridge, which was soon separated from the southeastern portion and moved eastward into Manitoba as a separate area of high pressure. During the 17th and 18th this area moved eastward and disappeared in Ontario.

VIII.—This number is given to the high pressure along the Atlantic coast, due to the westward movement of the Atlantic area of high pressure. The principal encroachments of this area may be catalogued as follows: 6th, a. m., at Jupiter, 30.12; 8th, a. m., Charleston and Savannah, 30.16; 9th, a. m., Augusta, 30.26; 10th, a. m., Cape Hatteras, 30.34; 12th, a. m., Augusta, 30.28; 14th, a. m., New York and Block Island, 30.32; 18th, a. m., Cape Hatteras, 30.18 to Jupiter, 30.16; 20th, a. m., Hatteras to Savannah, 30.22; and so continued, with little change, until the 25th, a. m., after which pressure was generally low on the Atlantic coast, while it rose in the interior and Rocky Mountain plateau region, but on the 29th, a. m., it was again high (30.34) in Nova Scotia and Newfoundland.

IX.—This appeared suddenly on the 23d, p. m., at the mouth of the St. Lawrence, moving rapidly southward in the rear of a depression (XI) that was moving eastward over the Gulf of St. Lawrence. It was central off the coast of Nova Scotia on the 24th, a. m., after which it stretched southwest and merged into the Atlantic low. In connection with the rising pressure, high northeast winds occurred at coast stations, and at 10.30 a. m. northeast storm signals were ordered for Narragansett and Woods Holl sections.

LOW AREAS.

The month of June has been marked by the appearance of a number of ill-defined and minor areas of low pressure in addition to a few that developed into important storms. It is believed that all depressions that are marked "Low" on the Daily Weather Map have been included in the following list:

I.—This depression appeared on the 1st, a. m., east of southern Florida, and after moving westward apparently disappeared over that peninsula on the 2d, p. m.

II.—This was a continuation of No. XII of the month of May. On the 1st, a. m., it was central in Montreal, and after moving westward it turned eastward and finally disappeared on the 4th, p. m., over the Gulf of St. Lawrence.

In connection with low area No. II the following wind signals were ordered: 1st, 10.30 a. m., Portland, Me., to Sandy Hook, change to northwest; 9.30 a. m., Buffalo, cautionary southwest; 11.30 a. m., Lake Huron and Sault Ste. Marie, cautionary southwest; 2d, 9.30 a. m., Buffalo, continue cautionary southwest.

III.—This was the southern end of a depression moving southeastward into Oregon. The central lowest pressure was, on the 3d, a. m., in Oregon, but on the 3d, p. m., in British Columbia, and from the 3d to the 7th this depression extended as a long trough north and south, with one or more ill-defined centers. By the 8th, p. m., it had become central in Manitoba, and a steady inflow of cold air from the southwest prevailed over the Pacific coast and Rocky Mountain regions. The map of the 9th, a. m., showed the isobars again stretching rapidly southeastward into Nebraska, with high winds and rains to the westward, but on the 9th, p. m., the center was again in Manitoba, after which it disappeared from our weather map, apparently by merging into No. VII.

In connection with low area No. III the following wind signals were ordered: 8th, 11 p. m., Red Wing, storm south-

east; 9th, 10.45 p. m., Red Wing and Duluth to Alpena, cautionary southeast; 10th, 11.15 p. m., Corpus Christi, storm southeast; 10.20 p. m., Red Wing, cautionary southeast.

IV.—This depression appeared on the 1st, a. m., in Saskatchewan, moved southeastward, and disappeared on the 1st, p. m., in Manitoba.

V.—This appeared on the 6th, a. m., in North Carolina, moved eastward, and disappeared on the 6th, p. m., off that coast.

VI.—After low area No. II passed over the Gulf of St. Lawrence on the 4th, pressure continued low in that region until the 7th, and in fact it was low during that period from Newfoundland westward to the Rocky Mountains. On the 7th pressure fell rapidly in Nova Scotia, New Brunswick, and Newfoundland, and the p. m. map seems to show a hurricane developing east of Nova Scotia and central in about N. 44°, W. 59°; but this must have moved northward and broken up over Newfoundland on the 8th and 9th, leaving a depression that is numbered VI, whose lower edge was at the mouth of the St. Lawrence on the 8th, p. m., and which, moving eastward, disappeared on the 10th, a. m., over Newfoundland. These depressions were undoubtedly only subsidiary features on the southern side of the more extensive depression that apparently prevailed from Montana and Alberta eastward to Labrador and Iceland, and subsequently moved southeastward over European Russia.

In connection with low area No. VI the following wind signals were ordered: 7th, 10 a. m., Port Huron, cautionary southwest; 10 a. m., Alpena and Sault Ste. Marie, cautionary northwest; 11 p. m., Red Wing and Duluth, cautionary southeast.

VII.—This number is given to the low pressure that occasionally stretches northward over Arizona toward Oregon. The principal minima of the month at Yuma were as follows: 2d, p. m., 29.75, at which time low No. III was simultaneously stretching southward from British Columbia; 4th, p. m., 29.72, at which time low No. III was still central in Alberta; 10th, p. m., 29.53, at which time low No. III had disappeared in the neighborhood of Hudson Bay, while low No. VII was central in Assiniboia, and low pressure prevailed from Saskatchewan to the Gulf of California, with high pressure over the south Atlantic States and the coast of northern California; 15th, p. m., 29.70, at which time the trough of low pressure had stretched northward from the Gulf of California to Oregon and beyond; 21st, p. m., 29.69, at which time this same pressure also prevailed at Tucson, and an extensive depression covered the plateau region from Mexico northward to Alberta; 26th, p. m., 29.73, at this time the Gulf of California formed the southern limit of a depression that covered the entire region between the western slope of the Rocky Mountains, the eastern slope of the Alleghenies, Mexico on the south, and Hudson Bay on the north; 30th, p. m., 29.73, at which time also areas of low pressure occupied the greater part of the region just indicated.

It is difficult to determine to what extent the low pressures in the Rocky Mountain and plateau regions must be considered as an apparent result of the reduction to sea level and to what extent a deficit of pressure really exists. It is evident from the direction of the wind that a small deficit must exist and would be shown even if observations were all reduced to a uniform level of 5,000 feet instead of sea level. It is, however, not necessary to assume that this large area of low pressure within the North American Continent is a simple static result of the rarity of the heated air; on the contrary, numerous areas of high pressure pass over the continent accompanied by the highest temperatures, and it is evident that these high temperatures are the direct result of the more rapid descent and the warming by compression of the air in the neighborhood of the highest pressure. These

areas of high pressure, therefore, represent the regions in which the overflow from the tropical and equatorial regions descends to the earth's surface at higher latitudes. The effect of high temperature and rarified air over the interior of the continent is to diminish the tendency of areas of high pressures to descend into this region, and when they do so they consist of warm air that has come from a short distance and descended rapidly instead of, as in the winter season, consisting of air that has come from a long distance and descended slowly and is, therefore, cold. The characteristic distinction between the motion of the air in the high areas of summer and winter is, therefore, that in the latter the air is descending less rapidly than in the former, which distinction is due to the fact that the soil most heated by the sun in the summer time is in a zone nearly 50° north of the corresponding zone in winter time. This is a part of the general distinction between tropic and temperate climates, as shown in the diagram on p. 262, *Am. Met. Journ.*, 1892, Vol. VIII.

VIII.—This was central on the 9th, p. m., in Alberta, having undoubtedly moved southeastward from British Columbia or Alaska while high No. III was approaching the coast of California and Oregon. In connection with low No. III there was maintained an extensive depression in the interior of the country until the 13th, at which time this central depression disappeared in western Nebraska. Its shape was generally that of a long trough, stretching north and south, whose central lowest pressure rapidly changed its position from one end to the other. High southeasterly winds usually prevailed on the easterly side of this trough and northerly winds on its west side, and the highest temperatures of the month occurred in Illinois, Wisconsin, and North Dakota on the 12th to the 14th in connection with these winds.

IX.—This depression appeared on the map of the 10th, p. m., at which time it was central in Maine, but it moved rapidly eastward or was broken up and merged into No. VI.

X.—This was central in Manitoba on the 14th, a. m., and apparently represents the northern end of the trough No. VIII, and was at the same time on the southern border of a low area extending further northward. After a little delay it moved rapidly eastward and disappeared over Newfoundland on the 17th.

XI.—This was central on the 16th, a. m., in eastern Nebraska, and after moving a little to the south, turned northeastward, passing over Lake Michigan on the 17th, and finally disappearing on the 19th in lower Canada.

In connection with low area No. XI the following wind signals were ordered: 17th, 10.20 p. m., Milwaukee, Chicago, Grand Haven, and Green Bay, storm northwest; 10.20 p. m., Alpena, storm northeast; 10.20 p. m., Port Huron, storm southeast; 18th, 12.10 p. m., lakes Erie and Ontario, cautionary southwest; 19th, 10.30 p. m., Duluth and Red Wing, storm southeast.

XII.—On the 16th, a. m., an area of low pressure existed in Nevada as a portion of a trough reaching northward into British Columbia. On the 16th, p. m., pressure was lowest in Alberta, but on the 17th, a. m., in Washington and Alberta. The center of this extensive depression appears to have first become visible as it moved southeastward on the 17th, p. m., in Alberta; it now moved eastward on the northern border of our stations, until on the 19th, a. m., a more important secondary (XIII) was formed in Wyoming, at the southern border of its trough-like extension.

XIII.—This was central in Wyoming on the 19th, a. m. It moved from north to northeast, reaching Manitoba on the 20th, p. m., and accompanied by severe local storms. It appeared then to have passed northward beyond our stations,

and was probably broken up and merged into the general depression of that region.

XIV.—This appeared as a low pressure in western Kansas on the 21st, a. m., and may be considered as due to the cyclonic circulation of the winds on and at a slight elevation above the earth's surface; but this was not sufficiently decided to perpetuate the low area, and its further development ceased.

XV and XVI.—No. XV appeared on the 21st, p. m., in Alberta. It moved east and then south, and was central on the 23d, a. m., in North Dakota, with a subsidiary low in western Kansas. The main depression now filled up, becoming a trough on the 23d, p. m., extending northward to the low pressure over the Canadian provinces, while the southern subsidiary depression, which is numbered XVI, after moving about irregularly, disappeared in Colorado on the 24th, p. m.

XVII.—Appeared on the 23d, p. m., in Alberta and was apparently the western part of the general depression of the interior. By the 25th, a. m., it had advanced eastward into Manitoba, after which it disappeared.

XVIII.—This appeared on the 24th, p. m., north of Lake Superior and was apparently the eastern end of the general depression that included Nos. XVII and XVIII. After moving east, it turned northeast and disappeared on the 25th, p. m., near the mouth of the St. Lawrence.

XIX.—This appeared in Athabasca on the 26th, a. m., and after moving southward into Alberta, it disappeared on the 27th, a. m., in Saskatchewan.

XX.—This was the trough that, on the 26th, p. m., connected No. XIX and No. VII. It was at that time central in Colorado. The 27th, p. m., it had moved into the southern portion of Minnesota and extended as a trough northward through Manitoba. On the 28th, a. m., it was central in Manitoba, after which it moved north and east beyond our stations and disappeared on the 30th, p. m. in Labrador.

In connection with low area No. XX the following wind signals were ordered: 27th, 10.30 p. m., Red Wing, lakes Huron, Michigan, and Superior, storm southeast; 28th, 10.25 a. m., Lake Erie, storm southeast; 10 a. m., Chicago and Milwaukee, change to storm southwest; 6.30 p. m., Milwaukee section, Green Bay and section, Grand Haven and section, Mackinaw section, Lake Huron, Marquette, Sault Ste. Marie, and Houghton section, change to storm southwest; 6.30 p. m., Duluth and Ashland section, change to storm northwest.

XXI.—This appeared on the 28th, a. m., off the coast of Maine, but disappeared without any further development.

XXII.—This appeared on the 28th, p. m., in Alberta as the eastern end of No. XX, which was then north of Lake Superior. It continued on the northern border of our stations and was central north of Manitoba on the 30th, p. m.

XXIII.—This was central in northern Florida on the 29th, p. m. It moved southeastward over the peninsula and disappeared on the 30th.

In connection with low area No. XXIII the following wind signal was ordered: 30th, 5 p. m., Charleston, storm northeast.

XXIV.—This appeared on the 28th, p. m., in Alberta and Athabasca, forming part of the general depression that extended southward to Mexico and northward to Hudson Bay. By the 30th, p. m., this depression was central in northern Manitoba, with a subsidiary low in eastern Nebraska and Arizona, while high pressures prevailed in Washington and near Newfoundland. The general distribution of pressure was, therefore, at this time very characteristic of this month, viz, high on the Atlantic and Pacific coasts, but low in the interior, with several special depressions.